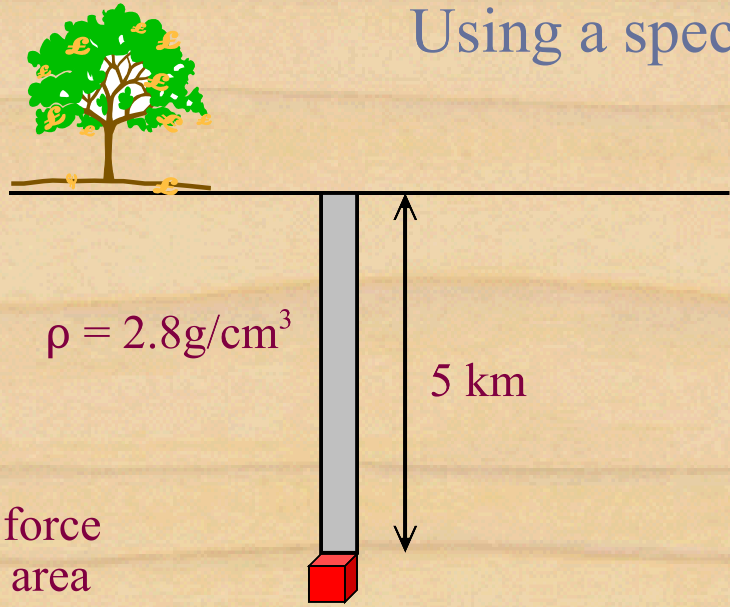
GY360 Structural Geology

Lecture notes on the dynamic analysis of stress

Calculation of Lithostatic Stress

Using a specified density of overburden and depth



F = force
A = area
m = mass
a = acceleration
F = ma

stress (σ) = $\frac{F}{A}$

Given a depth of burial of 5 km, density of 2.8, calculate the lithostatic stress on a one cm^3 volume.

$a = 980\ cm/sec^2$

F = ma

F = Vρa (where ρ = density, V = volume)

F =(ρ)(h)(b)a
(where h = height of column; b = area of base)

$F = (2.8 g/cm^3)(5.0 x 10^5 cm)(1.0 cm^2)(980 cm/sec^2)$

$F = [1,372,000,000\ (g)(cm)]/sec^2$
= 1,372,000,000 dynes

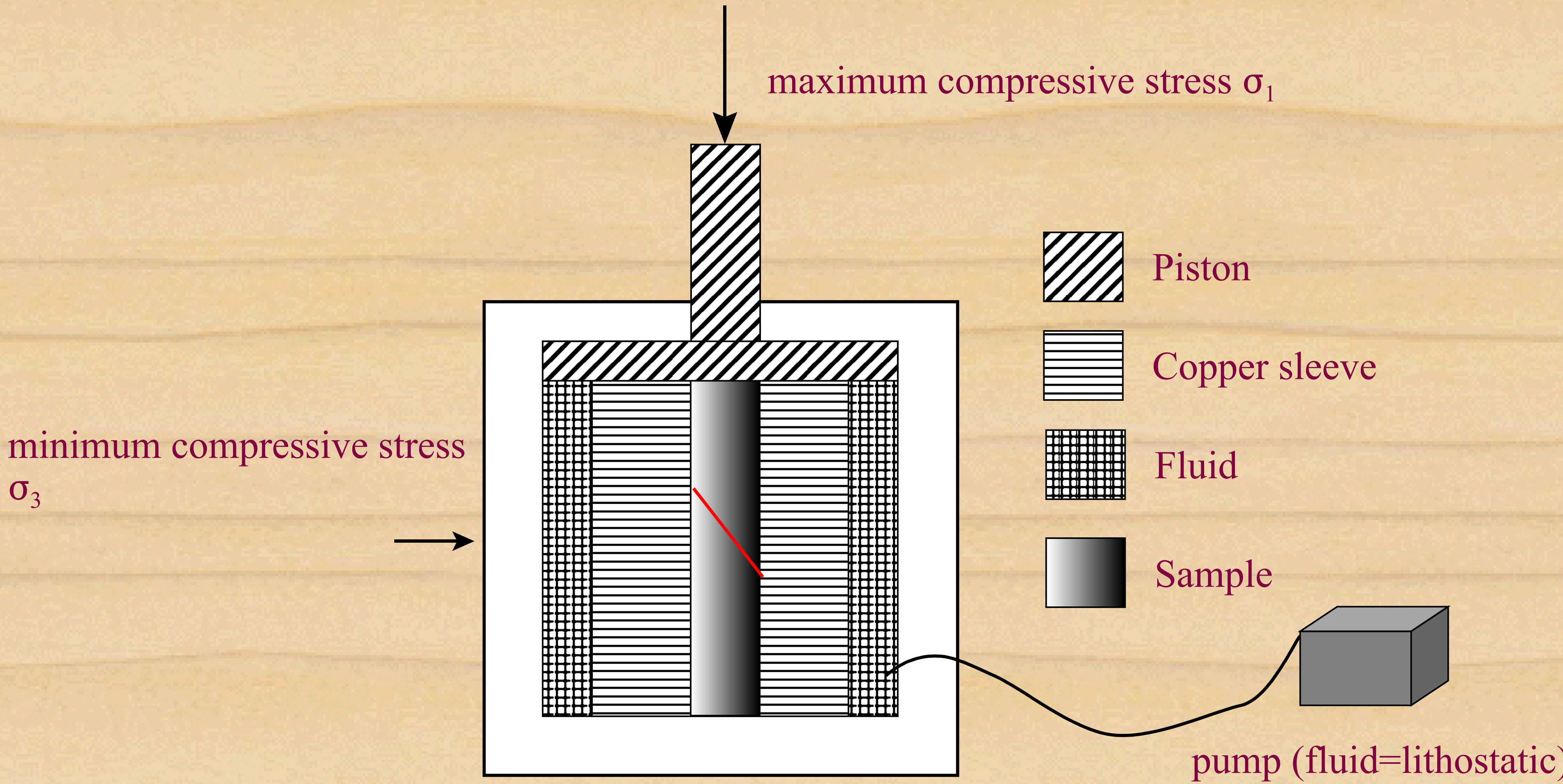
$\sigma = (1,372,000,000\ dynes) / cm^2 *$
$(1.0\ bar)/(1,000,000\ dynes/cm^2)$

σ = 1,372 bar = 1.372 kbar

Pressure gradient:
(5.0 km)/(1.372 kbar) = (3.64 km)/(kbar)

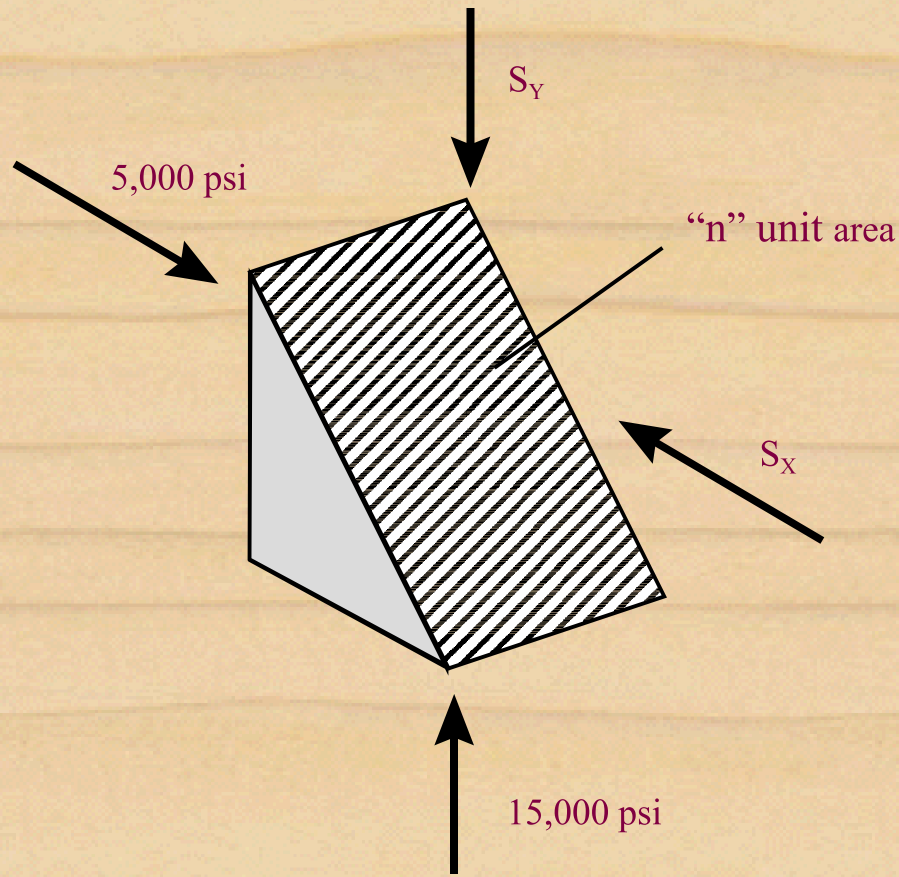
The Triaxial Stress Apparatus

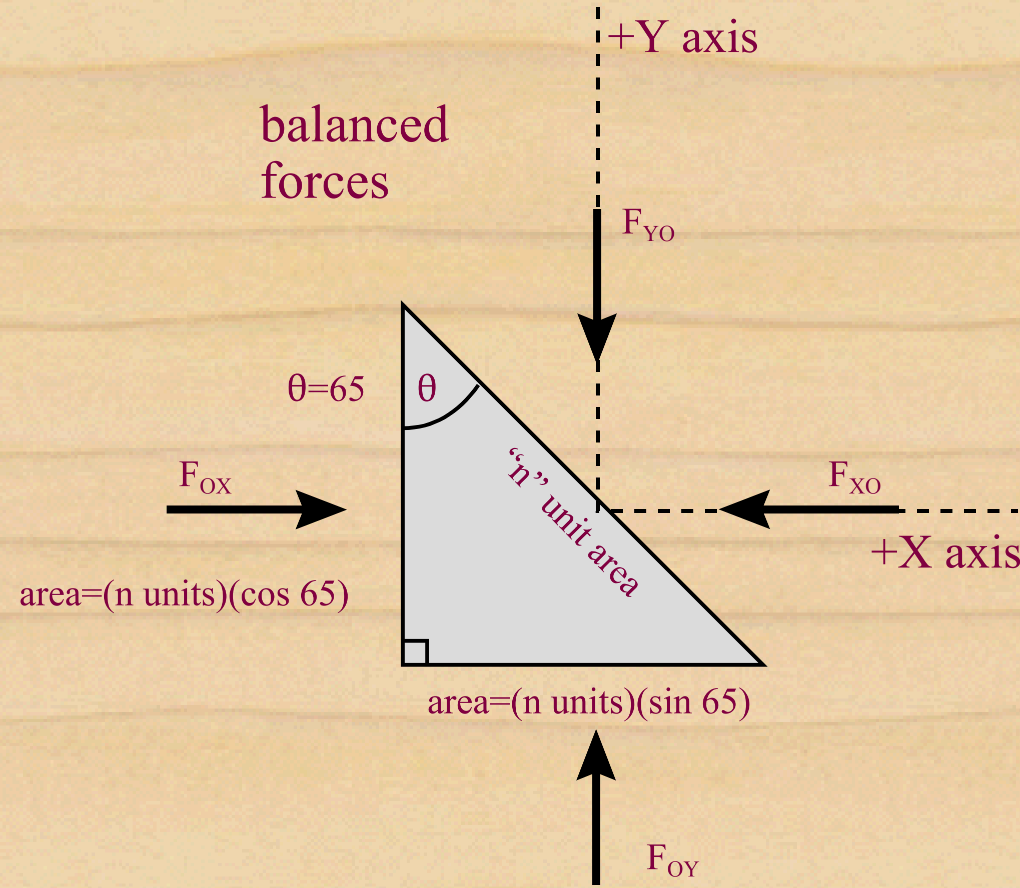
Otherwise known as the "Bomb"!



Calculation of Stress using Resolution of Forces

Triaxial stress apparatus example





Resolution of Forces

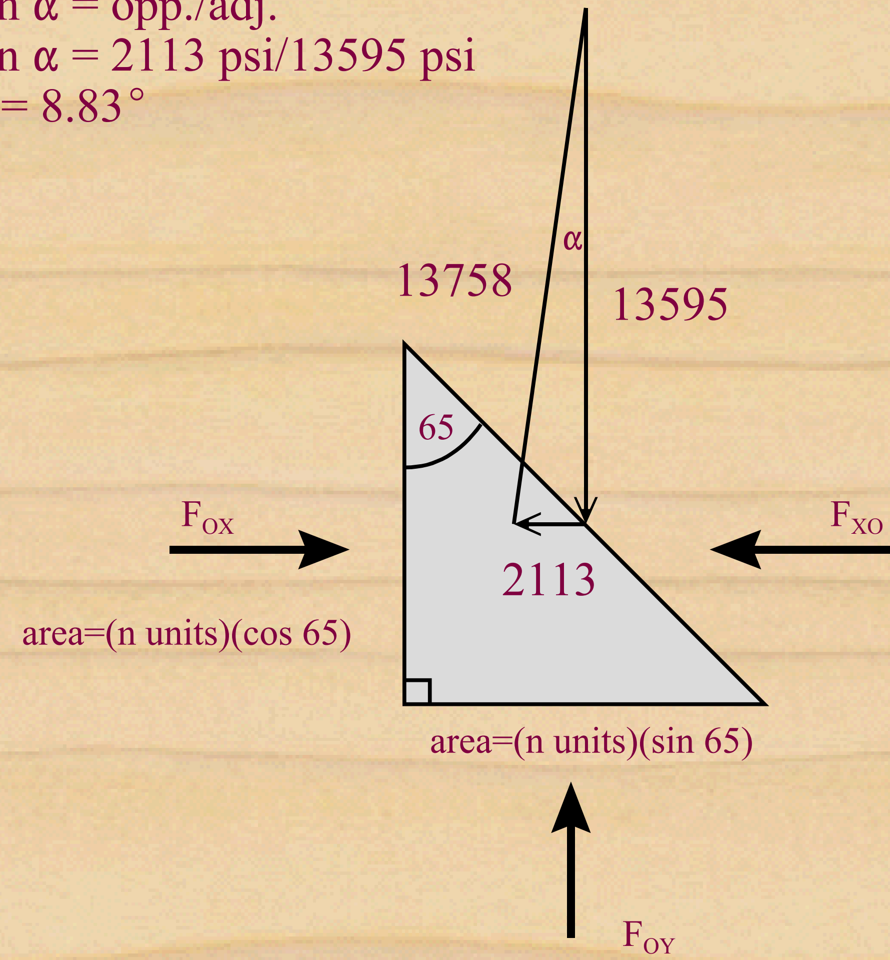
Using the balanced forces assumption

$\sigma = F/A$
$F = \sigma A$
$F_{xo} = F_{ox}$ (balanced forces)
$F_{xo} = S_x A = S_x(\text{n units})^2$
$F_{ox} = (5000\text{psi})(\cos 65)(\text{n units})^2$
$S_x(\text{n units})^2 = (5000\text{psi})(\cos 65)(\text{n units})^2$
$S_x = 2113$ psi

$S_y = (15000\text{ psi})(\sin 65)$
$S_y = 13595$ psi

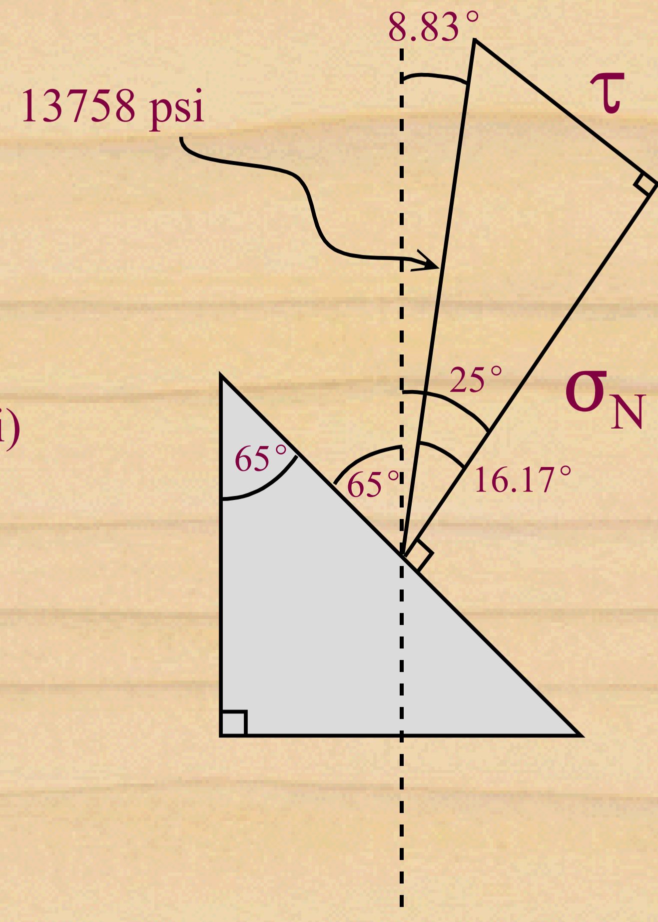
$\sigma^2 = S_x^{\ 2} + S_y^{\ 2}$
$\sigma^2 = (2113\text{psi})^2 + (13595\text{ psi})^2$
$\sigma = 13758$ psi

$\tan \alpha$ = opp./adj.
$\tan \alpha$ = 2113 psi/13595 psi
$\alpha = 8.83°$



Resolving Stress Tensor

Components of the stress tensor parallel and perpendicular to the potential shear plane

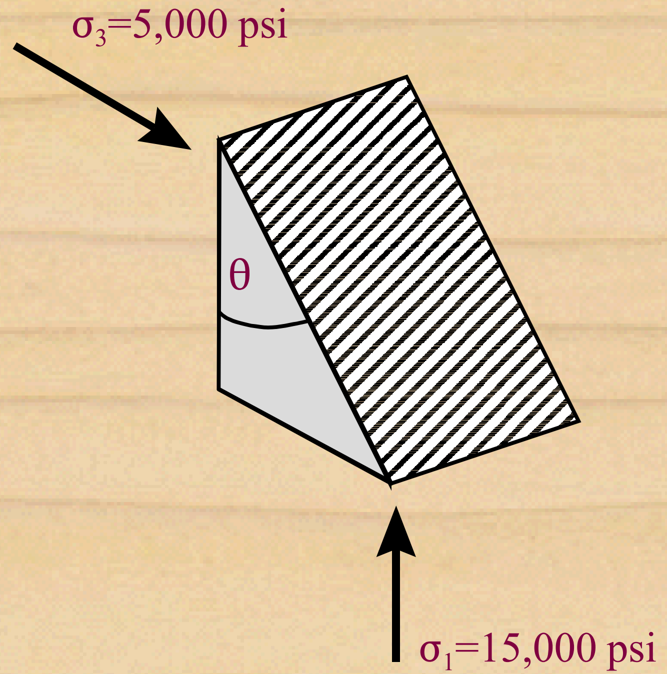


cos (16.17°) = (σ_N)/(13758 psi)
σ_N = 13214 psi
sin (16.17°) = τ/(13758 psi)
τ = +3831 psi

Table of Normal(σ) and Shear(τ) Stress

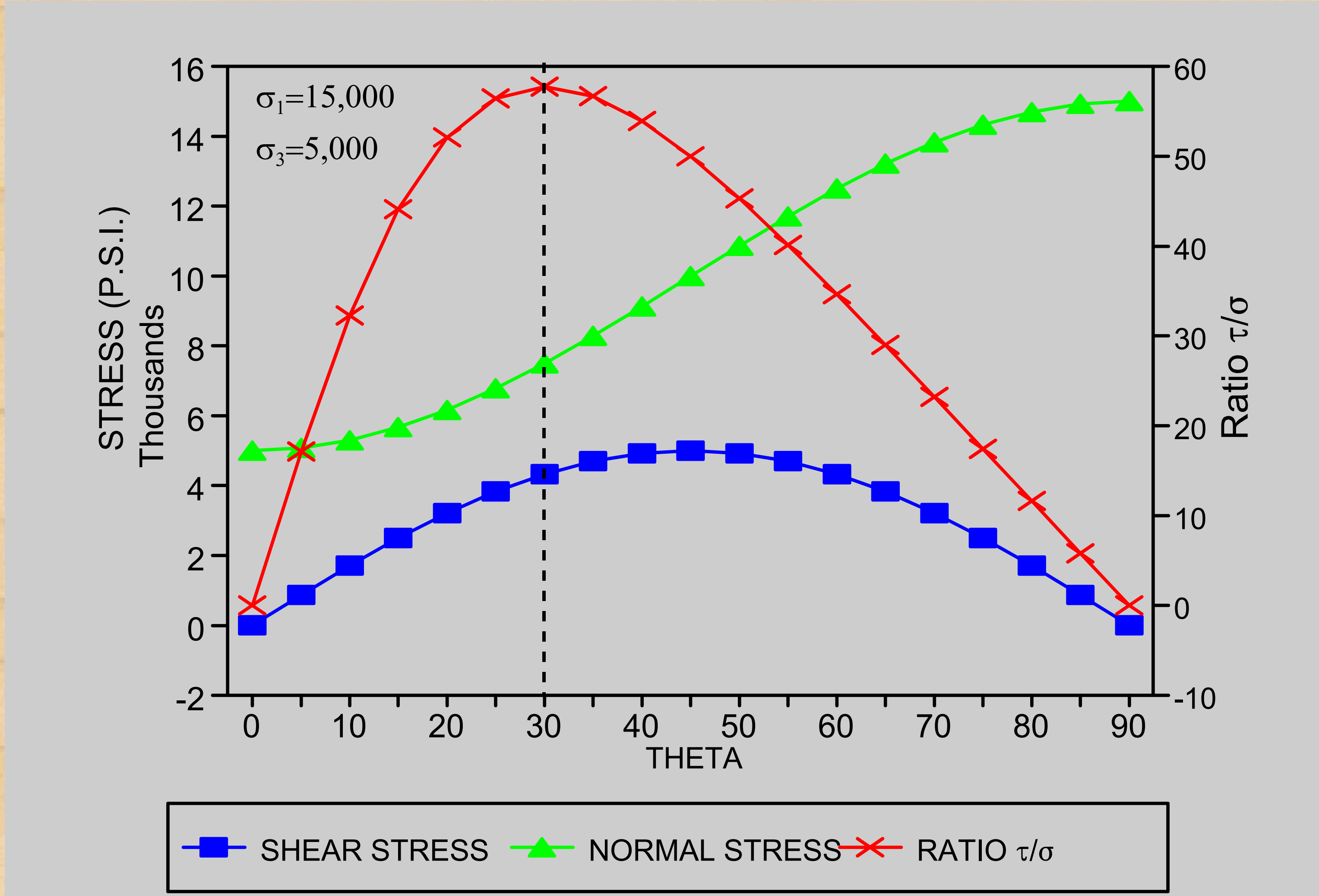
As a function of theta (θ) angle from potential shear plane

θ(angle with σ_1)	Normal Stress(σ)	Shear Stress(τ)	Ratio (τ/σ)
0	5000	0	0.0
5	5075	868	17.1
10	5301	1710	32.3
15	5669	2500	44.1
20	6169	3214	52.1
25	6786	3830	56.4
30	7500	4330	57.7
35	8289	4698	56.7
40	9131	4924	53.9
45	10000	5000	50.0
50	10868	4924	45.3
55	11710	4698	40.1
60	12500	4330	34.6
65	13213	3830	29.0
70	13830	3214	23.2
75	14330	2500	17.4
80	14698	1710	11.6
85	14924	868	5.8
90	15000	0	-0.0



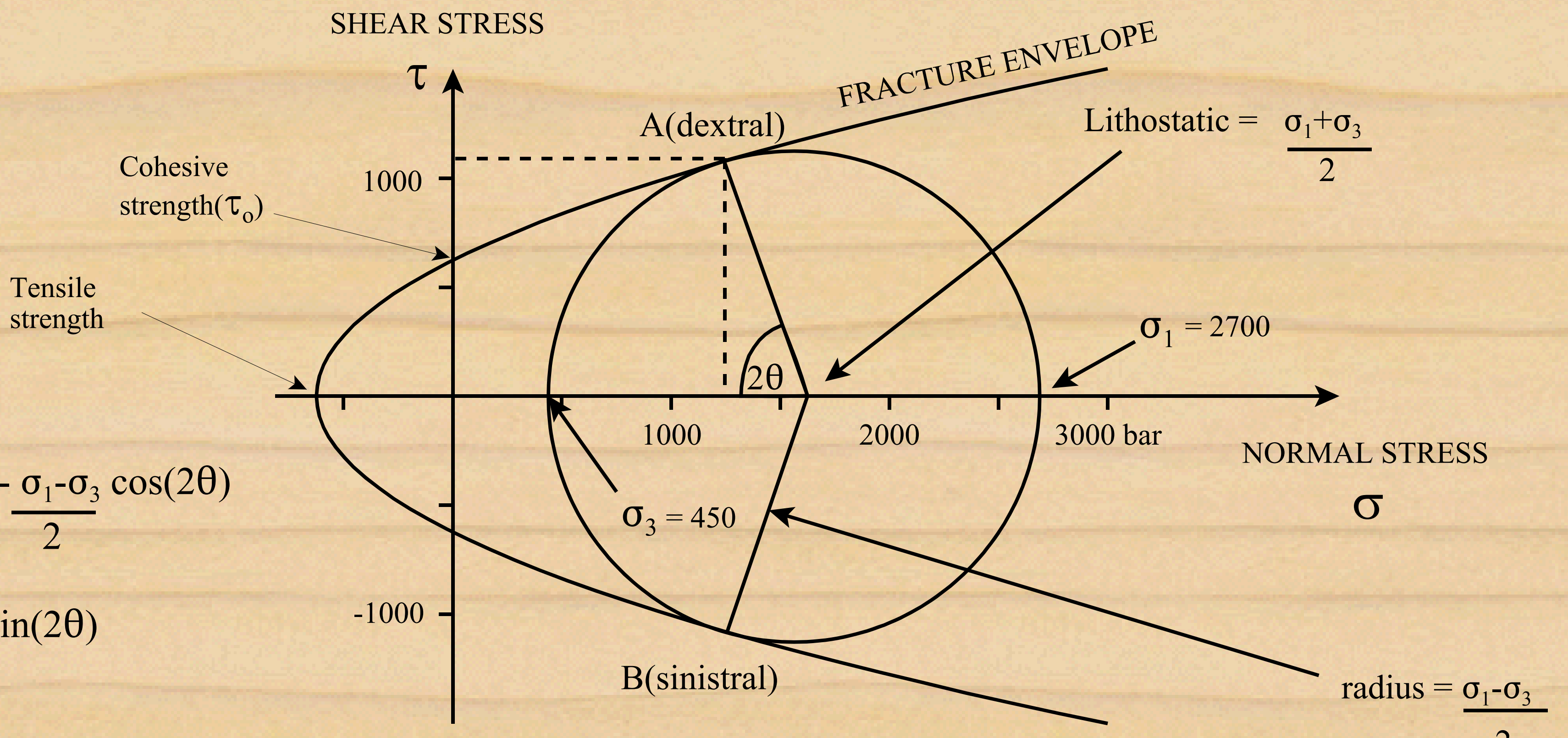
Normal and Shear Stress Values

As a function of theta angle



Mohr Circle for Stress

General equations for σ and τ



$$\sigma = \frac{\sigma_1+\sigma_3}{2} - \frac{\sigma_1-\sigma_3}{2}\cos(2\theta)$$

$$\tau = \frac{\sigma_1-\sigma_3}{2}\sin(2\theta)$$

NOTE: θ is the angle between the plane and the σ_1 direction.